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The impacts of Information and Communications Technology (ICT) and E-commerce on bilateral trade flows

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Abstract This study examines the impact of Internet and e-commerce adoption on bilateral trade flows using a panel of 21 developing- and least-developed countries and 30 OECD countries. Given the commitment of East African Community (EAC) to become the frontrunner in export-led economy across the African continent, special attention is dedicated to analyse the role of ICT and e-commerce on EAC's export performance. The empirical results indicate that better access to the modern ICT and adoption of e-commerce applications stimulate bilateral trade flows at various levels. The study notes that the efficient use of ICT equipped with highspeed internet and secured servers is a crucial milestone for unlocking the e-trade potentials for developing- and least-developed counties.

Keywords E-commerce · Bilateral trade · Gravity model · Developing- and least-developed countries

1 Introduction

It is widely acknowledged that trade is a crucial factor for economic growth. For developing and least-developed countries, earnings from exporting their goods and services to the Global North are considered as a vital source of foreign exchange that ease the pressure on the balance of payments and create employment opportunities (Thangavelu and Rajaguru 2004).

While technology transfer, international competition and economy of scales effects are seemingly related to exporting, several studies note potential benefits from

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importing as well. In particularly, studies indicate that imports of capital and intermediate goods from the Global North have a direct positive effect on firms' productivity in the Global South through embodied high-level technology and advanced production methods (Grossman and Helpman 1991; McKinnon 1964; Thangavelu and Rajaguru 2004). Therefore, through the channel of bilateral trade between the South and North, firms in the developing and least-developed countries may learn to reproduce products or adopt high-level technology from their trading partners in the Global North, either for sale domestically or for the world market.

In an increasingly globalised environment, trade landscape has profoundly changed and reshaped by the Information and Communications Technology (ICT) based innovations that gives firms access to larger markets, allowing them to expand their customer base, increase their scale and raise profits. It also forces firms to confront world-class competitors, exposes them to new ideas and expertise, and encourages them to stay abreast of market trends (April and Cradock 2000; Clarke and Wallsten 2006; Freund and Weinhold 2002, 2004).

On the one hand, a country's technology infrastructure plays a critical role in creating a nurturing environment for ICT evolvement and adoption. On the other hand, the Internet technologies create the basis for continual advances with respect to new goods and services, new markets and new business models in the digital economy. This in return provides the basis for e-commerce development.

In a broad sense, international e-commerce involves cross-border and/or cross-country transactions over the internet which generates substantial savings in transaction costs. The most important cost-saving aspect of e-commerce is reduction in travel, administration, communication and market search costs. E-commerce is being promoted in the global south economies because it enables their producers/exporters to overcome traditional limitations associated with restricted access to information, higher market-entry cost, and isolation from potential markets (Aw and Hwang 1995; April and Cradock 2000). It also fosters entrepreneurship by encouraging small and medium enterprises (SMEs) to identify new market niche or gaining economies of scale through managing their operations and coordinating value chains across borders (Davidow and Malone 1992; Steinfield and Klein 1999; Panagariya 2000).

There are three types of e-commerce: Business-to-Business (B2B), Business-to-Consumer (B2C), and Consumer-to-Consumer (C2C). The B2B commerce consists of a wide range of inter-company transactions, including wholesale trade and trade in intermediate goods and services. The B2C is a segment of e-commerce where enterprises sell goods and services to consumers. Although the estimated value of global B2C (US$1.2 trillion) in 2013 is considerably smaller than B2B (US$15 trillion), the B2C sector experienced much more rapid growth due to increasing use of the Internet, the emergence of specialised online shops, and global integration of trade (UNCTAD 2015).

The third type of e-commerce (C2C) is related to the selling of goods and services among consumer. In this market, a growing number of specialised e-commerce firms such as Alibaba (China), Amazon (USA), eBay (USA), Rakuten (Japan), and TradeMe (New Zealand) act as intermediaries allowing individuals to sell new and used goods. While each of these different e-commerce segments relates to a particular interaction between buyers and sellers, all have a potential role in promoting possible new kinds of international trade and transactions in goods and services. It can be safely assumed that

e-commerce would become the mainstream of international (export and import) trade in the coming decades.

Although the growth of internet access is widely acknowledged, it imposes numerous integration challenges for developing countries and Least Developed Countries (LDCs) to participate in this e-trade mode. For instance, the International Telecommunication Union (ITC) (2015) estimates about 4 billion people from developing countries remain offline, and only 89 million people living in the LDCs use the Internet. To better explain international trade and ICT adoption linkages involved in e-commerce, this study employs an augmented gravity model of trade to examines the impact of ICT and e-commerce on bilateral trade flows between 30 countries of the Organisation for Economic Cooperation and Development (OECD) and 21 developing- and least-developed countries. Given the East African Community (EAC)[1] member states' commitment in transformation of their economies with export-led growth, the study further analyses the nexus between the EAC's export performance and different means of ICT and e-commerce adoptions.

The rest of the paper is set out as follows: Section 2 provides a brief literature review on the definition of e-commerce, and the nexus of ICT and international trade. Section 3 discusses the data, methodology and model specifications utilised in analyses of various ITC and e-commerce variables noted above. Section 4 presents the empirical results followed by concluding remarks in the final section.

2 Brief literature review

2.1 Definition of E-commerce

There are various definitions of e-commerce in the literature. In the academic literature, e-commerce is broadly referred to as an activity that is part of information and communication technology (ICT) activities. For instance, Zwass (1996. p.3) defines e-commerce as "the sharing of business information, maintaining business relationships, and conducting business transactions by means of telecommunications networks." Treese and Stewart (1998, p.5) define e-commerce as "the use of global Internet for purchase and sale of goods and services, including services and support after the sale." Kalakota and Whinston (1996, p.3) define e-commerce as "the delivery of information, products/services, or payments via telephone lines, computer networks or any other means", while Kauffman and Walden (2001, p. 3) emphasize "the Internet as a medium for enabling end-to-end business transactions." It also applies (ibid, p.3) "…in dotcom [and] Internet-only business settings, as well as more traditional business settings where the new channel of the Internet is being used alongside existing channels."

Amongst global intergovernmental organisations, the universal definitions of e-commerce seem to be transaction-oriented. For instance, OECD (2009) defines that e-commerce is the sale or purchase of goods or services, conducted over computer networks by methods specifically designed for receiving or placing orders. Those methods exclude the goods and services are made by telephone calls, facsimile or

[1] The EAC includes: Burundi, Kenya, Rwanda, Tanzania, and Uganda.

manually typed e-mail, although the payment and the ultimate delivery of the goods or services do not have to be conducted online.[2] World Trade Organisation (WTO) (2013, p.ii) defines e-commerce as "the sale or purchase of goods or services conducted over computer networks by methods specifically designed for the purpose of receiving or placing of orders."

In this study, the international e-commerce is defined as consisting of cross-border transactions that involve online orders leading to the delivery of goods and services from exporting countries to importing countries. The next section discusses the linkage between ICT infrastructure and international trade.

2.2 ICT and international trade

In the early empirical studies, growth theory was the theoretical vantage point to observe and examine the contribution of exogenous technological progress to economic growth (see Solow 1956; Swan 1956). For high-income countries, it has seen the technological advancement and technical efficiency gained through research and development (R&D), while the technical efficiency gains of the middle- and low-income countries are found in the adoption of technologies already developed in technologically advanced countries (Caselli et al. 1996; Klenow and Rodriguez-Clare 1997; Hall and Jones 1999). As technology infrastructure progresses, the contribution of penetration and adoption of ICT to a country's economic growth is observed. For instance, using cross-sectional time series data for 60 countries over 13 years, Hardy (1980) found that the usage of telephones per capita promotes growth in GDP per capita a year later.

In recent years, the empirical studies have been pointed out the growth-enhancing linkages between ICT adoption and international trade. Freund and Weinhold (2002) estimate the impact of the Internet use on bilateral trade in services in a selected sample of developed and middle income countries for the period of 1995–1999, indicating that a 10% age point increase in the growth of web hosts (as proxy for Internet adoption) in a country leads to an increase of 1.7 and 1.1 percentage point in exports of services and imports of services, respectively. In a companion paper, Freund and Weinhold (2004) further examine the role of Internet adoption in bilateral trade flows in goods. They find that a 10-percentage point increase in the adoption of Internet leads to a 0.2 percentage point increase in trade in goods. They estimate that, on average, the growth of internet web hosts contributes a 1 percentage point to annual growth in the panel of 56 countries between 1997 and 1999.

Tang (2006) investigates how the usage of different means of telecommunications affects US imports of differentiated goods from 1975 to 2000. With a fixed-effect model approach, the study finds that adoptions of fixed line telephones, mobile phones, and internet connection in the exporting countries have significant impact on US imports of differentiated goods, indicating that a 10% rise in exporter's internet adoption rate increases the total exports of goods to the US by 1 %. By utilising cross-sectional data on the total exports of goods in 2001 for 26 developed countries

[2] See OECD (2009) at http://www.oecd-ilibrary.org/sites/sti_scoreboard-2011en/06/10/index.html?contentType=&itemId=%2Fcontent%2Fchapter%2Fsti_scoreboard-2011 64en&mimeType=text%2Fhtml&containerItemId=%2content%2Fserial%2F20725345&accessItemIds=

and 72 developing countries, Clarke and Wallsten (2006) find that greater internet penetration promotes trade flows from developing countries to developed countries, but no significant effect is found when the trade flow is from developed countries to developing countries.

Vemuri and Siddiqi (2009) analyse the effect of ICT infrastructure and internet penetration on international trade for a panel of 64 countries between 1985 and 2005. They find that a 10 percent increase in internet usage leads to a 2% increase in bilateral trade. While Choi (2010) indicates that a doubling of internet usage would increase a country's export of services by 2–4% among 151 countries from 1990 to 2006, Liu and Nath (2013) find internet subscriptions and internet hosts are positively and significantly related to trade performance in 40 emerging market economies in 1995–2010.

Yushkova (2014) uses the business Internet usage index to estimate the effect of the Internet on total exports of goods in 2011 for 40 countries (OECD countries plus Brazil, China, India, Indonesia, Russia and South Africa). She finds that the Internet usage by business communities in both exporting and importing country has a positive link with the export flows between these countries. In line with Yushkova (2014), the current study further examines the nexus of e-commerce (i.e., B2B and B2C) adoption and bilateral trade flows between the Global South and North using the latest available bilateral trade data. The next section discusses data and variable definitions, methodology and model specification.

3 Data, methodology and model specification

3.1 Data and variable definitions

The dataset in this study is assembled using a variety of sources (see Table 1). The dataset includes a panel of 21 developing- and least-developed countries[3] and 30 OECD[4] countries to empirically examine whether the emergence of e-commerce plays a role in boosting developing- and least-developed countries' export performance.

The sample countries are further divided into three subsample groups: 1) *South-to-North*; 2) *North-to-South*; and 3) *EAC-to-Rest of the World.*[5] The subsamples group of *EAC-to-Rest of the World* represents the bilateral trade between EAC member countries and their counterparts, while the *South-to-North* subgroup implies trade directions from countries considered as the global south economies to countries that are referred to as

[3] They are: Brazil, Brunei, Burundi, Cambodia, China, India, Indonesia, Kenya, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Russia, Rwanda, Sri Lanka, South Africa, Thailand, Tanzania, Uganda, and Vietnam,

[4] They are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Kingdom, and United States.

[5] Rest of the World includes Australia, Austria, Belgium, Brazil, Brunei, Cambodia, Canada, China, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Luxembourg, Malaysia, Myanmar, Nepal, Netherlands, New Zealand, Norway, Poland, Pakistan, Philippines, Portugal, Russia,Slovak Republic, Slovenia, South Africa, Sri Lanka, Spain, Sweden, Switzerland, Thailand, United Kingdom, United States, and Vietnam.

Table 1 Variable definition and source

Variable	Definition	Source
$lnTrade_{ij}$	Log of total exports of goods from country i to country for the year 2014 in current US$	OECD STAN Bilateral Trade Database by Industry and End-use category.
$Distance_{ij}$	Physical distance between the capital cities of country i and country j in kilometres	French Research Centre in International Economics (CEPII)
$Contigious_{ij}$	Country i and country j shares the same border (Yes =1, No =0)	CEPII
$Language_{ij}$	Country i and country j shares at least one common language (Yes =1, No =0)	CEPII
$Colony_{ij}$	Country i and country j have a former colonial link (Yes =1, No =0)	CEPII
$Telephone_i$	Fixed telephone subscriptions per 100 people in country i.	World Development Indicators (WDI) database (World Bank, 2014).
$Telephone_j$	Fixed telephone subscriptions per 100 people in country j.	WDI 2013–2014
$Cellphone_i$	Mobile cellular subscriptions per 100 people in country i.	WDI 2013–2014
$Cellphone_j$	Mobile cellular subscriptions per 100 people in country j.	WDI 2013–2014
$Broadband_i$	Broadband subscriptions per 100 people in country i.	WDI 2013–2014
$Broadband_j$	Broadband subscriptions per 100 people in country j.	WDI 2013–2014
$InternetSecurity_i$	Secured internet services per 1 million people in country i.	WDI 2013–2014
$InternetSecurity_j$	Secured internet services per 1 million people in country j.	WDI 2013–2014
$InternetUser_i$	Number of Internet users per 100 people in country i.	WDI 2013–2014
$InternetUser_j$	Number of Internet users per 100 people in country j.	WDI 2013–2014
ShippingCost	Cost to export (US$ per container)	WDI 2013–2014
$lnMarketSize_{ij}$	Relative market size between the country i and country j for the year 2014 in constant US$.	WDI 2013–2104
$lnGDPPC_i$	Log of GDP per capita in country i for the year 2014 in current US$.	WDI 2013–2014
$lnGDPPC_j$	Log of GDP per capita in country j for the year 2014 in current US$.	WDI 2013–2014
$B2B_i$	Extent of B2B internet use in country i. An index valued in the range between 1 and 7 (best).	INSEAD, The Global Information Technology Report 2014–2015, World Economic Forum (WEF).
$B2B_j$	Extent of B2B internet use in country j. An index valued in the range between 1 and 7 (best).	WEF, 2014–2015.
$B2C_i$	Extent of B2C internet use in country i. An index valued in the range between 1 and 7 (best).	WEF, 2014–2015.
$B2C_j$	Extent of B2C internet use in country j. An index valued in the range between 1 and 7 (best).	WEF, 2014–2015.
The Nexus of E-commerce and EAC trade performance		
$B2B_i$	Extent of B2B internet use in country i. An index valued in the range between 1 and 7 (best).	INSEAD, The Global Information Technology Report 2013–2014,

Table 1 (continued)

Variable	Definition	Source
$B2B_j$	Extent of B2B internet use in country j. An index valued in the range between 1 and 7 (best).	WEF, 2013–2014.
$B2C_i$	Extent of B2C internet use in country i. An index valued in the range between 1 and 7 (best).	WEF, 2013–2014.
$B2C_j$	Extent of B2C internet use in country j. An index valued in the range between 1 and 7 (best).	WEF, 2013–2014.

the global north economies. The *EAC-to-Rest of the World* indicates the total amount of final goods the EAC member countries exported to the rest of sample countries.

The value of total exports of goods from country set (*i*) to country set (*j*) is obtained from the OECD STAN Bilateral Trade Database. Several dummy variables are considered for characteristics trading partners have in common. These variables include language (*Language*), former colonial links (*Colony*) and national borders (*Contiguous*), and take the value of 1 when countries' characteristics are shared and 0 otherwise. The dummy variables along with geographic distance (*Distance*) between the two sets of countries are derived from French Research Centre in International Economics (CEPII).

Data on nominal GDP and GDP per capita, shipping cost per container, and ICT-related infrastructure variables (such as telephone subscriptions, mobile cellular subscriptions, broadband subscriptions, number of secured Internet servers, and number of Internet users) for country set *i* and *j* are derived from the World Bank's *World Development Indicators Database*.

The e-commerce indices (i.e., B2B and B2C) are drawn from the World Economic Forum's Executive Opinion Survey (Dutta et al. 2015) as part of the networked readiness index. The index consists of 54 indicators and organised by 10 pillars. The index of B2B measures the extent of ICTs adoption for business-to-business transactions, while B2C indicates the extent of business Internet use for selling their goods and services to consumer.

These indices are under the business usage sub-index (7th pillar) and measured on a 1-to-7 scale (with 7 being the best possible outcomes).[6] The B2B and B2C Internet use indices are calculated for the period 2014/2015, hence, to capture the effects of e-commerce readiness and adoption between country set *i* and country set *j*, a 1-year time lag is considered.

To overcome the data limitations in the nexus of e-commerce and EAC export performance, the value of total exports of goods from EAC countries (i.e., country set *i*) to *Rest of the World* (i.e., country set *j*) is obtained from the OECD STAN Bilateral Database for the year 2013. Therefore, the 2013/2014 B2B and B2C Internet use indices are used to examine the role of e-commerce in EAC countries export performance. Other associated macroeconomic variables are for the year 2013 (see Table 1).

[6] see the Global Information Technology Report 2015, at http://www3.weforum.org/docs/WEF_GITR2015.pdf

The dependent variable of bilateral trade flows between country *i* and country *j* ($\ln Trade_{ij}$) takes the logarithm of ($exports_{ij}$ + 0.001) to address the problem of zero trade flows in the dataset (see Anderson 1979; Helpman et al. 2008). The descriptive statistics for the explanatory variables are presented in Table 2.

As seen in Table 2, the total exports of goods from countries *i* to countries *j* is about US$3.2 billion (full sample), while a total of US$1.4–1.8 billion worth of trade was commenced between South and North in 2014. In the nexus of e-commerce and EAC export performance, it is estimated that the export trade flows from the EAC member countries to the rest of world (ROW) is about US$3700 million in 2013.

The average shipping cost is relatively high for the exporters in the North (US$1092 per container) compares to their counterparts in the South (US$1346 per container). The average shipping cost of goods from EAC-to-ROW is estimated at US$1958 per container. The level of ICT infrastructure development is also marred with the B2B and B2C indices. As seen in Table 2, countries in the North have higher ICT adaptation rate (i.e., telecommunication subscriptions, internet security and usage) in comparing with those in the South, in particularly, EAC countries have the lowest scores across the ICT-related variables. The ranking of selected countries by B2B and B2C Internet usage is presented in Table 3 below.

Most of the countries in the Global North are ranked in the world's top 50 except for Poland, Greece and Italy. The extent of e-commerce Internet usage varies across the developing- and least-developed countries, for instance, Malaysia (21), South Africa (37) and Kenya (45) are in the top 50 spots in B2B Internet use, whereas Malaysia (15), Indonesia (28), China (34), Russia (36) and Brazil (37) are occupied in the top 50 in B2C Internet use (see Table 3).

The regional development in the B2C e-commerce segment also differs considerably. For instance, in Africa, the expansion is linked to the rapid growth of mobile solutions for making digital transactions, whereas the patterns are highly diverse in Asia ranging from the world's largest B2C e-commerce market in China to countries in which e-commerce is only beginning to emerge (UNCTAD 2015). The next section discusses the methodology and model specification.

Table 2 Descriptive statistics

Variable	Full Sample (1011)	South-to-North (514)	North-to-South (497)	EAC-to-ROW (206)
Trade (in US$ billion)	3.2	1.8	1.4	0.0037
Nominal GDP (in US$ billion)	3.8	1.3	2.8	0.015
Nominal GDP per capita (US$)	29,415	11,097	39,522	1593
ShippingCost (US$ per container)	1221	1346	1092	1958
Telephone	23	8	39	0.34
Cellphone	115	107	123	63
InternetSecurity	591	32	1165	3
Broadband	18	6	31	0.1
InternetUser	57	32	83	7
B2B Index	5.2	4.6	5.5	4
B2C Index	4.9	4.4	5.5	3.6

World Bank (2014), WEF (various)

Table 3 The extent of B2B and B2C internet usage indices in 2014/2015

	South					North			
	B2B		B2C			B2B		B2C	
	Rank	Value	Rank	Value		Rank	Value	Rank	Value
Brunei	59 (148)	5	75 (143)	4.5	Australia	28 (143)	5.5	16 (143)	5.7
Cambodia	83 (143)	4.6	109 (143)	3.8	Austria	15 (143)	5.7	24 (143)	5.5
Indonesia	51 (143)	5.1	28 (143)	5.4	Belgium	22 (143)	5.6	31 (143)	5.2
Malaysia	21 (143)	5.6	15 (143)	5.7	Canada	23 (143)	5.6	17 (143)	5.7
Myanmar	136 (143)	3.4	129 (143)	3.2	Czech Republic	25 (143)	5.6	12 (143)	5.8
Nepal	129 (143)	3.9	114 (143)	3.6	Denmark	27 (143)	5.6	23 (143)	5.5
Pakistan	97 (143)	4.3	102 (143)	3.9	Estonia	2 (143)	6.1	11 (143)	5.8
Philippines	52 (143)	5.1	58 (143)	4.7	Finland	5 (143)	6.1	33 (143)	5.2
Sri Lanka	57 (143)	5	56 (143)	4.8	France	44 (143)	5.2	29 (143)	5.3
Thailand	59 (143)	4.9	49 (143)	4.9	Germany	29 (143)	5.5	13 (143)	5.8
Vietnam	49 (143)	5.1	54 (143)	4.9	Greece	102 (143)	4.3	81 (143)	4.3
Brazil	84 (143)	4.6	37 (143)	5.1	Hungary	30 (143)	5.5	46 (143)	4.9
Russia	66 (143)	4.8	36 (143)	5.1	Iceland	12 (143)	5.8	22 (143)	5.5
India	119 (143)	4	95 (143)	4.1	Ireland	35 (143)	5.3	45 (143)	5
China	61 (143)	4.9	34 (143)	5.2	Israel	31 (143)	5.5	21 (143)	5.5
South Africa	37 (143)	5.3	65 (143)	4.6	Italy	103 (143)	4.3	73 (143)	4.4
Burundi	142 (143)	2.9	140 (143)	2.6	Japan	4 (143)	6.1	3 (143)	6.1
Kenya	45 (143)	5.2	61 (143)	4.7	Luxembourg	11 (143)	5.8	19 (143)	5.6
Rwanda	81 (143)	4.6	100 (143)	4	Netherlands	9 (143)	5.9	4 (143)	6
Tanzania	117 (143)	4	121 (143)	3.5	New Zealand	16 (143)	5.6	9 (143)	5.9
Uganda	114 (143)	4	125 (143)	3.4	Norway	8 (143)	5.9	7 (143)	5.9
					Poland	98 (143)	4.3	52 (143)	4.9
					Portugal	24 (143)	5.6	30 (143)	5.3
					Slovak Republic	26 (143)	5.6	25 (143)	5.5
					Slovenia	38 (143)	5.3	47 (143)	4.9

Table 3 (continued)

South					North			
B2B		B2C			B2B		B2C	
Rank	Value	Rank	Value		Rank	Value	Rank	Value
				Spain	46 (143)	5.1	48 (143)	4.9
				Sweden	10 (143)	5.9	5 (143)	6
				Switzerland	6 (143)	6	10 (143)	5.8
				United Kingdom	3 (143)	6.1	1 (143)	6.3
				United States	17 (143)	5.6	2 (143)	6.3

The Global Information Technology Report 2015 (Dutta et al. 2015)

South refers to the global south economies, whereas North regards to the global north economies. Total numbers of countries ranked are in parenthesis. The B2B and B2C Internet use index are calculated based on a 1-to-7 (best) scale. The B2B and B2C indices for Brunei are taken from The Global Information Technology Report 2014

3.2 Methodology and model specification

The notion that trade is a vital factor for a country's economic growth is not new, which can trace back to Adam Smith's (1776) literature '*An Inquiry into the Nature and Causes of the Wealth of Nations*'. In the literature, Adam Smith frequently emphasised that trade between countries would improve economic productivity by expanding the size of markets and gaining economies scales, thereby rising one's economic performance. In 1821, Ricardo introduced the theory of comparative advantage, which explained why it is beneficial for two countries to trade, even though one of them may be able to produce both goods or services more cheaply than the other. According to his theory, a country can reap welfare gains by specialising in the production of a good or service in which it has the lowest opportunity cost in relative to the other. Since then, vast studies on developing and least-developing countries have long focused on how international trade can best contribute a country's overall economic growth and reasons for countries to participate in global trade (see Krugman et al. 2015).

To study the magnitude of trade flows between countries, the gravity model of trade is viewed as an effective analytical tool to do so (Tinbergen 1962; Poyhonen 1963; Leamer and Levinsohn 1995; Anderson and van Wincoop 2003; Disdier and Head 2008). The gravity mode of trade was formally applied by Tingergen (1962) and Poyhonen (1963) to explain bilateral trade flows between distant countries using the functional form of Newtonian gravity. Based on the Newtown's law of universal gravitation, the basic form of gravity model can be express as:

$$X_{ij} = C\frac{M_i M_j}{D_{ij}^2} \tag{1}$$

Equation 1 implies that a mass of goods or services (M_i) at origin i is attracted to a mass of demand for goods or services (M_j) at destination j, and the potential trade flow decreases by the physical distance (D_{ij}) between i and j. C is the gravitational constant term, and Xij is the predicted movement of goods or services from i to j. Based on Eq. 1, the gravity mode of bilateral trade takes the following form:

$$X_{ij} = a_0 (Y_i)^{a_1} \left(Y_j\right)^{a_2} \left(D_{ij}\right)^{a_3} \mu_{ij} \tag{2}$$

Where X_{ij} is the value of bilateral exports from i to j; a_0, a_1, a_2, a_3 are the unknow parameters; Y_i and Y_j represent the gross domestic product per capita (GDPPC) as a proxy for the exporters and importers economic masses; D_{ij} is the distance between country-pairs; and μ_{ij} is the disturbance term.

Given the bi-directional features of the predicted movement of goods from country i to country j at one moment in time, the current study applies the panel data technique of fixed-effects estimation to examine the contribution of ICT infrastructure and e-commerce penetration to bilateral trade.[7] In addition, the Hausman test is used to choose between fixed- and random-effect model specifications, and the test statistics is 85.87 with 1% level of significant implying that fixed-effect estimation approach is a better choice (Wooldridge 2002).

Drawn from the literature on bilateral trade (Tinbergen 1962; McCallum 1995; Lejarraga and Shepherd 2013), explanatory variables such as the relative size of economies, GDP per capita, geographical distance between trade partners, common border, common language, and former colonial link are included in the present analysis. In the nexus of ICT and bilateral trade performance, the current study follows the estimation strategies in Freund and Weinhold (2004) and Yushkova (2014) but also contributes several innovations in estimating the contribution of e-commerce Internet use to international trade. The underlying augmented gravity model with fixed-effects takes the following form:

$$\begin{aligned} \ln\text{Trade}_{ij} = {} & \beta_0 + \beta_1 lnMarketSize_{ij} + \beta_2 lnGDPPC_i + \beta_3 lnGDPPC_j + \beta_4 Contiguous_{ij} \\ & + \beta_5 Language_{ij} + \beta_6 Colony_{ij} + \beta_7 lnDIST_{ij} + \beta_8 lnShippingCost_{ij} \\ & + \beta_9 Telephone_i + \beta_{10} Telephone_j + \beta_{11} Cellphone_i + \beta_{12} Cellphone_j \\ & + \beta_{13} Broadband_i + \beta_{14} Broadband_j + \beta_{15} InternetSecurity_i + \beta_{16} InternetSecurity_j \\ & + \beta_{17} InternetUser_{ij} + \beta_{18} B2B_{ij} + \beta_{19} B2C_{ij} + \varepsilon_{ij} \end{aligned} \tag{3}$$

where

$lnTrade_{ij}$	is the natural log of total exports of goods from country i to country j in current US$;
$lnMarketSize_{ij}$[8]	is the relative market size between country i to country j (measured in the natural log of nominal GDP of each country);
$lnGDPPC_i$	is the natural log of nominal GDP per capita in country i;

[7] See Egger (2000) for the random- and fixed-effects model specifications. It is suggested that a random-effect model is preferred for estimating trade flows through a randomly drawn sample of trade partners, while the fixed-effect model is a better choice for estimating trade between an ex-ante predetermined selection of economies.

[8] In line with Egger (2000), the coefficient of $lnMarketSize_{ij}$ defined as $ln\left[1-\left(\frac{GDP_{it}}{GDP_{it}+GDP_{jt}}\right)^2-\left(\frac{GDP_{jt}}{GDP_{it}+GDP_{jt}}\right)^2\right]$

$lnGDPPC_j$	is the natural log of nominal GDP per capita in country *j*;
Contiguous	is a dummy variable that takes 1 if the country *i* and country *j* shares the same border and 0 otherwise;
Language	is a dummy variable that takes 1 if the country *i* and country *j* shares at least one common language and 0 otherwise;
Colony	is a dummy variable that takes 1 if the country *i* and country *j* have a former colonial link;
lnDIST	is the log of physical distance between the capital cities of country *i* and country *j* (in kilometres);
$lnShippingCost_{ij}$	is the log of shipping cost per container from country *i* to country *j* in US$;
Telephone	is the fixed telephone subscriptions (per 100 people);
Cellphone	is the mobile cellular subscriptions (per 100 people);
Broadband	is the fixed broadband subscriptions (per 100 people);
InternetSecurity	is secured internet servers (per 1 million people);
InternetUser[9]	is an interaction term represents the internet usage in country *i* and country *j*;
B2B[10]	is an interaction term represents the extent of business-to-business use in country *i* and country *j*;
B2C[11]	is an interaction term represents the extent of business-to-consumer use in country *i* and country *j*;
ε_{ij}	is the disturbance term.

Apart from non-technology variables as suggested in the literature of gravity model of trade, Eq. (3) includes five ICT-related infrastructure indicators (i.e., telephone subscriptions, mobile cellular subscriptions, broadband subscriptions, number of secured internet servers) and two e-commerce Internet usage indices (i.e., B2B and B2C). The estimations are made for the year 2014 for the full-sample, South-to-North, and North-to-South groups. In the case of EAC country-specific analysis, the panel estimations are made for the year 2013 due to the unavailable bilateral trade data, except for Burundi and Uganda. The estimation results are presented and discussed in the following section.

4 Empirical results

4.1 Empirical results: full sample analysis

Table 4 presents the results pertaining to the estimation of four different model specifications of Eq. (3). Column 1 presents full sample estimation of ICT-bilateral

[9] The interaction term is defined as: $InternetUser_{ij} = \frac{\text{InternetUser}_i \quad \text{InternetUser}_j}{max_{ab}(\text{Internet}_a \text{Internet}_b)}$ (a), where $InternetUser_i$ and $InternetUser_j$ are internet users (per 100 people) in country *i* and *j*, respectively.

[10] $B2B_i$ and $B2B_j$ is the business-to-business readiness indices as measured on a 1-to-7 (best) scale for the country *i* and country *j*, *B2B* is formulated in the same way as in equation (a).

[11] $B2C_i$ and $B2C_j$ is the business-to-consumer readiness indices as measured on a 1-to-7 (best) scale for the country *i* and country *j*, B2C is formulated in the same way as in equation (a).

Table 4 Estimation results for the impact of ICT & E-commerce on bilateral trade, 2013/2014

	Full sample (1)	South-to-North (2)	North-to-South (3)	EAC-to-ROW (4)
$lnMarketSize_{ij}$	0.205 (2.44)**	0.267 (2.15)**	0.219 (1.76)*	0.676 (3.02)***
$lnGDPPC_i$	1.071 (4.47)***	0.382 (2.87)***	1.17 (2.15)**	0.686 (2.63) ***
$lnGDPPC_j$	0.264 (1.72)*	0.402 (1.69)*	0.763 (2.08)**	0.784 (2.19)**
$Contiguous_{ij}$	0.325 (1.01)	-	-	-
$Language_{ij}$	0.306 (2.01)**	0.287 (1.98)**	0.219 (1.59)	1.316 (5.67)***
$Colony_{ij}$	0.674 (1.98)*	0.306 (1.16)	-	0.074 (0.17)
$lnDIST_{ij}$	-3.27E04 (−2.38)**	-2.03E04 (1.51)	-2.07E04 (1.45)	−0.0438 (−2.1)**
lnShippingCost	−0.926 (−4.41)***	−1.23 (−3.52)***	−1.02 (5.47)***	−2.15 (−4.3)***
$Telephone_i$	0.028 (2.81)***	0.022 (2.26)**	0.0023 (0.6)	0.192 (1.79)*
$Telephone_j$	0.051 (2.34)**	0.037 (1.81)*	0.0129 (1.1)	0.011 (2.16)**
$Cellphone_i$	0.067 (2.66)***	0.027 (3.83)***	0.011 (1.42)	0.198 (2.35)**
$Cellphone_j$	0.041 (2.15)**	0.013 (2.18)**	0.009 (0.9)	0.033 (0.57)
$Broadband_i$	0.042 (2.11)**	0.099 (3.66)***	0.073 (0.83)	0.151 (1.95)*
$Broadband_j$	0.055 (2.09)**	0.042 (2.37)**	0.028 (1.21)	0.004 (0.99)
$InternetSecurity_i$	0.0008 (2.83)***	0.002 (4.63)***	0.026 (1.15)	0.046 (3.06)***
$InternetSecurity_j$	0.0011 (2.3)**	0.016 (3.84)***	0.043 (1.3)	0.002 (0.32)
$InternetUser_{ij}$	0.123 (2.8)***	0.325 (3.67)***	0.022 (0.42)	0.469 (4.97)***
$B2B_{ij}$	0.0683 (3.32)***	0.0985 (3.56)***	0.0349 (0.54)	0.259 (1.64)
$B2C_{ij}$	0.0044 (3.96)***	0.0089 (2.5)**	0.0041 (0.94)	0.041 (0.93)
Constant	−5.54 (−3.43)***	−6.45 (−1.93)*	−33.88 (−3.81)***	−22.49 (−15.41)***
No. of observations	1011	514	497	206
Adjusted R^2	0.7653	0.7871	0.7428	0.7066

*, ** and *** indicate that the coefficient is significant at the 10%, 5% and 1% level respectively. Numbers in parentheses are *t*-statistics. See Table 1 for the variable definitions. Dependent variable: $lnTrade_{ij}$ = log ($Export_{ij}$ + 0.0001). *South* refers to the sample where country *i* is developing and least-development countries. The estimation result for the *EAC to Rest of World* is for the year of 2013

trade nexus followed by South-to-North (column 2), North-to-South (column 3), and EAC-to-ROW (column 4). Under the South-to-North trade estimation, *Country i* refers to exporters from developing- and least-developed countries (South), *Country j* are importing countries in the Global North, and vice versa for the North-to-South. The sample estimation strategies apply to EAC-to-ROW estimation.

Across columns 1 to 4, the relative market size ($lnMarketSize_{ij}$) of exporting and importing countries is an important determinant in explaining trade variations among participating countries, implying that a 1 %age point increase in the potential market of country *j* for goods from country *i* leads to an increase in exports of goods from country *i* to country *j* by 0.205–0.677 percentage point. As proxies for the exporting and importing countries' purchasing power, the coefficients for the nominal GDP per capita for country *i* ($lnGDPPC_i$) and country *j* ($lnGDPPC_j$) are statistically significant and positively related to bilateral trade and remain significant across all columns in Table 4, with the estimate coefficients ranging from ranging from 0.264 to 0.902 for country *j*, and from 0.382 to 1.17 for country *i*. The findings are consistent with other gravity-approach studies in explaining bilateral trade variations, which suggest that higher purchasing power with relatively larger market size lead to a higher demand for importing goods between trading countries (see Hans 1966; Deardorff 1995). Contiguity ($Contiguous_{ij}$) has an expected sign but statistically insignificant in the full sample estimation, although one would expect countries with a common border would

trade more. This is probably because market access, tariff and non-tariff measures imposed by the trade agreements become more complex than a few decades ago, and goes clearly beyond the border. The estimated coefficients of $Language_{ij}$ and $Colony_{ij}$ are significant and positive, implying that having a common language and a colonial political tie (or a regional trade agreement) boost trade flows from country *i* to country *j*, South-to-North and EAC-to-ROW.

The coefficient of geographical distance ($lnDistance_{ij}$) is negative and significant in Full Sample and EAC-to-ROW estimations, suggesting that the combination of longer distance and shipment time would discourage trading partners to trade for goods that required speedy transactions. The shipping cost ($lnShippingCost_{ij}$) has a negative and significant effect on trade between country *i* and country *j*, indicating a one-percentage point increase in the shipping cost per container decreases bilateral trade volumes by 0.923 percentage point (Column 1). The magnitude of shipping cost effects on bi-directional trade varies among the different estimation groups. For instance, a one-percentage point increase in the shipping cost will decrease trade flows from EAC to ROW by 2.15 percentage point, followed by trade declines in South-to-North (−1.23) and North-to-South (−1.02).

The estimated coefficients of ICT and e-commerce Internet usage variables have various impacts on bilateral trade flows among different estimation groups (i.e., columns 1–4 in Table 4). The coefficients of ICT variables (i.e., *Telephone & Cellphone*) in columns 1 and 2 are positive and significant, indicating that two-way telecommunications between exporters and importers with good ICT facilities benefit both trading partners. For instance, a 10% increase in the number of fixed and mobile phones in both exporting and importing countries increase bilateral trade by 0.28–0.67% in Full Sample and 0.13–0.37% in South-to-North.

Despite the various degrees of fixed telephone line infrastructure across the EAC member countries (i.e., Burundi, Kenya, Rwanda, Tanzania, and Uganda), having a reliable landline is crucial for EAC traders to engage in the international trade. It estimates that a 10% increase in the fixed telephone subscriptions ($Telephone_i$) in EAC member states would boost exports by 1.92%. Mobile phone penetration ($Cellphone_i$) also contributes a 1.98% boost in EAC's export performance if there is a 10% increase in mobile phone subscription.

Having better access to the high-speed broadband and secured servers enhances trade performance between the trading partners. As seen in Table 4, the estimated coefficients of $BroadBand_{ij}$ and $InternetSecurity_{ij}$ have a positive and significant effect on trade flows between country *i* and country *j*, while traders either in the Global South or in the EAC countries particularly benefited from availability of high-speed Internet and secured servers. As per column 2, a 10% increase in the number of secured serves and broadband subscriptions in the Global South will boost trade by 0.02% and 0.99%, respectively. This is also the case for the EAC countries in which the broadband subscriptions and secured servers are positively correlated with trade.

The interactive coefficient of $InternetUser_{ij}$ (as a proxy for internet penetration between the trading countries) is positive and significant across the estimation groups except for the North-to-South trade direction. The estimation results indicate that a 10-percentage point increase in bilateral internet adoption will lead to an increase in trade by 1.23 percentage point in Full Sample, 3.25 percentage point in South-to-North, and 4.69 percentage point in EAC-to-ROW. As the coefficients of $BroadBand_i$, $InternetSecurity_{ij}$

and $InternetUser_{ij}$ in EAC-to-ROW implies that being connected to the Internet, use of high-speed broadband and secured servers are important ingredients for exporters/producers and enterprises in the EAC to overcome traditional limitations associated with restricted access to information on potential markets for their goods and services.

To unlock EAC's export potential to participate in global trade, development efforts have been made through the Backhaul System (EABS) providing EAC member countries with access to submarine cables (The New Times, 2010).[12] The recent development in ICT such as "undersea fibre-optic cables have encircled Africa's coastlines and begun the long journey inland. Telecommunications providers are investing in 3G and subsidizing smartphone ownership. Innovative solutions are emerging that allow for the delivery of small pieces of the Internet event to basic handsets. At the same time, digital payment services are becoming more important and various online marketplaces are spreading" (UNCTAD 2015, p.25). The findings are consistent with the general consensus that internet expansion promotes international trade and reduces communication and transaction costs with the aid of more efficient logistics and warehousing (Venables 2001; Freund and Weinhold 2004; Clarke and Wallsten 2006; Liu and Nath 2013). For instance, Freund and Weinhold (2004) find that growth of the number of internet hosts by 10 percentage points boosts a country's exports by 0.2 percentage points, while Clarke and Wallsten (2006) indicate that a higher internet penetration rate in developing economies improves export performance from developing economies to developed economies. Liu and Nath (2013) find that internet subscriptions and web hosts have a positive and significant effect on exports in emerging market economies.

As the main point of focus in this study, the significant linkages are found between the extent of importing and exporting countries for e-commerce Internet usage and exports of goods from country i to country j, with the estimated coefficients of 0.0683 ($B2B_{ij}$) and 0.0044 ($B2C_{ij}$) at one percent significance level, indicating that for every 10-percentage point increase in e-commerce Internet usage, trade increases by 0.683 and 0.044 percentage point respectively. As per the estimation result of column 2 pointed out that the readiness of developing and least-developed countries for global e-commerce is more likely to benefit from South-to-North bilateral trade. The results show that for a 10-percentage point increase in B2B- and B2C-type e-commerce Internet adoption in the global south economies, South-to-North trade flows increase by 0.985 and 0.089 percentage point.

It is worth noting that while the variables of ICT and e-commerce Internet usage underscore a significant effect on South-to-North trade flows, no significant relationship is found from North-to-South, except for mobile phone subscriptions (see Column 3 in Table 4). It is possible to suggest that most of exporters/producers/enterprises and consumers in the Global North already have greater access to the Internet, and are equipped with greater skillsets in conducting business online (i.e., B2B, B2C and C2C), whereas being able to connect with reliable IT networks present a greater trade advantage if the exporters/producers in the Global South are aiming to sell their products online to developed countries. In other words, the ICT based technologies encourage individuals and enterprises to search for the best

[12] http://www.newtimes.co.rw/section/article/2010-01-15/15692/

service providers or producers regardless of physical distance (Davidow and Malone 1992; Bailey and Bakos 1997; Panagariya 2000; Egger and Lassman 2012).

As per EAC-to-ROW, the coefficients of B2B and B2C Internet usage are positive but not statistically significant, implying a need for further e-commerce development in the EAC region. Indeed, as identified by UNCTAD (2015), p.25), the major barriers for adopting e-commerce effectively in Africa "remain in areas such as transport and logistics, inadequate legal frameworks, and limited purchasing power". As shown in Table 3, the extent of B2B and B2C penetration varies among EAC member countries. For instance, Kenya is ranked at 45th (B2B) and 61st (B2C) for its e-commerce adoption, followed by Rwanda (81st, 100th), Uganda (114th, 125th), Tanzania (117th, 121st), and Burundi (142nd, 140th).

To address this disparity in e-commerce adoption in the region, a reliable and uninterrupted Internet connectivity is a prerequisite for unlocking the e-trade potentials for the EAC member countries. Table 5 shows a great divide in broadband cost and download speed between OECD and EAC groups. Amongst EAC members, Burundi has the highest broadband cost at US$100 per month with slowest download speed(128kps), followed by Uganda (US$39.92), Kenya (US$34.99), Tanzania (US$18.96), and Rwanda (US$17.43). therefore, an integrated tariff for broadband subscriptions is needed for the EAC region with the aim of making high-speed broadband available, affordable and accessible.

By lowering broadband cost in Burundi would encourage more entrepreneurs, traders, exporters, small business owners to use the Internet as an effective means not only to conducting business within the EAC region but also at the global level. Meeting the challenge of lowering the broadband Internet cost as a whole, the EAC members should encourage greater uses of e-commerce related technologies by gradually reducing market distortions while building up effective competition enforcement, as it shown in the case of opening the M-Pesa mobile money platform to competition in Kenya (see box 1).

Box 1 Opening the M-Pesa mobile money platform to competition

Safaricom's mobile money system is a well-known success story. It enables to grow quicklybecause Kenya's banking regulators initially decided to take a hands-off approach. For seven years, Safaricom maintained a dominant position through exclusivity agreements locking agents into the system. Initially, such arrangements were perhaps justified because Safaricom incurred high costs developing the system. But in 2014, Kenya's Competition Authority changed the rules and opened the system to alternative mobile operators. The Transaction cost of [money] transfers of up to KSh500 (US$4.91) fell from KSh66 to KSh44 (US$0.43).

World Development Report 2016 (World Bank 2016, p. 32)

The overall findings above confirm that the level of ICT infrastructure and the networked readiness for e-commerce adoption play an important role in boosting export growth by encouraging firms/producers/exporters, especially those who are in developing and least-developing countries to increase trade in response to the proliferation of global e-commerce value chains. It is also shown that the role of ICT as an enabler for e-commerce by accommodating the e-commerce based technology, innovation and diffusion. The estimation results suggest that with a greater Internet penetration and reliable IT networks, e-commerce can provide firms/producers/exporters in the Global South with opportunities for accessing new international markets at low-cost and

Table 5 Average broadband cost per month: EAC member countries

	Price (US$)	Download speed
OECD	22.78	1000kps
EAC		
Burundi	100	128kps
Kenya	34.99	256kps
Rwanda	17.43	256kps
Tanzania	18.96	256kps
Uganda	39.92	256kps

The average broadband cost per month in OECD countries is reported in September 2014 at http://www.oecd.org/sti/broadband/oecdbroadbandportal.htm#PRICES; The average monthly broadband tariff plan is targeted for business communities in the EAC member countries. The tariff is quoted in July 2012, except for Rwanda (which is recorded in 2015); The tariff has drawn from Google Fusion Tables at https://www.google.com/fusiontables/ DataSource?docid; The average monthly broadband tariff in Rwanda is calculated based on *Airtel* (see http://africa.airtel.com/)

minimal capital investment, for improving competitiveness and customer services, and for reducing trade cost via more efficient logistics and warehousing (Venables 2001).

5 Conclusion

This study uses gravity model estimation technique to examine the impact of Internet and e-commerce adoption on bilateral trade with a panel of 51 countries (21 middle- and low-income countries, and 30 OECD countries). The empirical results indicate that better access to the modern ICT and e-commerce applications boost bilateral trade flows among the different regression groups (i.e., Full Sample, South-to-North and EAC-to-ROW).

Bilateral trade flows between the South and North are significantly influenced by the level of Internet penetration, of B2B and B2C Internet adoptions, and number of broadband subscriptions and secured servers. However, no significant relationship is found when the bilateral trade flows are reversed. In the nexus of e-commerce and EAC export performance, the empirical findings suggest that having a reliable and uninterrupted Internet connectivity and encouraging greater use of digital technologies in the region is a prerequisite for unlocking the e-trade potentials for the EAC countries to compete in the global trade.

The empirical results obtained in this study highlight a great potential of e-commerce for developing- and least-developing countries. In the nexus of the EAC-to-ROW, the EAC must improve the access to the physical infrastructure for e-commerce by pursuing technical and development assistance programmes offered by the Intergovernmental organisations. These programmes could also be achieved within the purview of bilateral official development assistance or other development programmes administered by international and regional organisations.

The role of B2B and B2C e-commerce as a potential booster of trade in the Global South, yet the digital divide leaves many behind. For instance, most of EAC countries have the lowest scores in the extent of B2B and B2C Internet usage (see Table 3) as the result of limited purchasing power, inadequate legal frameworks for ICT facilitation

and regulation (UNCTAD 2015). In bridging the digital divide, it requires the EAC member states working together to make broadband available, affordable and accessible to the bloc. Meeting the challenge of providing an integrated low-pricing scheme for the high-speed Internet subscriptions in the bloc, the EAC should encourage greater use of e-commerce applications and technologies by gradually reducing market distortions while building up effective competition enforcement (World Bank 2016).

At the national level, the internet-based export development among EAC member states should focused on two main areas: 1) infrastructure and logistics; and 2) capacity building and training. Firstly, the need to overcome infrastructural bottlenecks in telecommunications and transport system must be addressed prior to unlocking the potential of e-commerce for the bloc. Improvements should be made in the following areas:

- Improve national roads and railway networks, logistic links to ports and airports;
- Improve transport governance and taking effective measures against antitrust and corruption;
- Establish efficient import and export procedures for e-commerce (including fast track handling of intermediate goods under e-commerce transaction);
- Upgrade ICT infrastructure with tax incentives for private sector's participations and encourage foreign investment in ICT-related sectors;
- Upgrade courier services by improving the coverage of postal home delivery and encourage the small- and medium-sized enterprises (SMEs) to participate in this sector.

Access to technology and ICTs must also combined with relevant skills, opportunities and capacities, thus it is vital to extend access to digital education services and new capability training schemes. While the countries in the South have abundant cheap labours, there still remains the issue of developing IT literacy and education to ensure the quality and size of the IT workforce. Support should be given on aligning curricula with computer science and IT-related courses throughout schools. Vocational training should be in line with the subjects of international business and management, business communication, cross-cultural and language learning, as well as website development and business marketing skills.

In the context of e-commerce participation, practical training should be given on converting paper-based information into a digital format, integrating logistics operations, financial administration, production formation, and managing a network of customers and suppliers. This will involve arranging workshops on organisational and management issues for exporters and producers. They need to know which e-commerce marketplaces and web-based information sources may be relevant to their products and services. They also need to be informed about the destination country's e-marketplace entry requirements and regulations (i.e., customs duties and procedures, the level of online security, Consumer and Sales Laws, online payments and taxes regulations, business subject to intellectual property rights and infringements, roaming charges via mobile devices, and product or service certification). Government and the associated agencies can help fill this gap by establishing an e-commerce specific information centre to assist exporters and producers or individuals who are interested in global e-commerce participation.

Appendix

Table 6 A and B present the correlation matrix for the variables used in the gravity model of Eq. 1

A

	lnTradeij	lnMarketSize	lnGDPPC	lnGDPPC	Contiguous	Language	Colony	lnDIST
lnTradeij	1							
lnMarketSize	0.036	1						
lnGDPPC	0.233	0.087	1					
lnGDPPC	0.337	0.122	0.097	1				
Contiguous	0.071	0.025	0.051	0.029	1			
Language	0.035	0.058	0.053	−0.09	-0.036	1		
Colony	0.055	−0.09	−0.109	0.094	0.186	0.1201	1	
lnDIST	−0.02	−0.01	0.133	−0.1	−0.35	0.2091	−0.071	1
lnShippingCost	−0.35	−0.23	−0.475	0.22	0.075	0.1383	0.095	0.293
Telephone	0.197	0.014	0.835	−0.68	0.042	0.1317	0.104	0.1
Telephone	0.202	0.013	0.59	0.706	0.043	0.1175	0.164	0.07
Cellphone	0.31	0.055	0.115	−0.27	0.104	0.1073	0.015	0.128
Cellphone	0.373	0.089	0.146	0.283	0.066	0.2582	0.01	0.201
InternetSecurity	0.112	0.013	0.24	0.207	0.027	0.1846	0.075	0.143
InternetSecurity	0.071	0.07	0.248	0.263	0.031	0.1514	0.068	0.138
Broadbandij	0.42	0.049	0.417	0.443	0.11	0.0806	0.017	0.141
InternetUserij	0.39	0.046	0.266	0.127	0.022	0.0152	0.052	0.125
B2Bij	0.45	0.006	0.27	0.213	0.012	0.0477	0.071	0.203
B2Cij	0.414	0.009	0.349	0.255	0.014	0.1005	0.068	0.365

B

	lnShippingCost	Telephone	Telephone	Cellphone	Cellphone	InternetSecurity	InternetSecurity	Broadbandij	InternetUserij	B2Bij	B2Cij
lnTradeij											
lnMarketSize											
lnGDPPC											
lnGDPPC											

Table 6 (continued)

Contiguous											
Language											
Colony											
lnDIST											
lnShippingCost	1										
Telephone	0.069	1									
Telephone	0.038	0.259	1								
Cellphone	0.036	−0.08	−0.08	1							
Cellphone	0.037	−0.09	−0.07	0.163	1						
InternetSecurity	0.161	0.177	0.184	0.098	0.177	1					
InternetSecurity	0.171	0.195	0.186	0.21	0.21	0.454	1				
Broadbandij	0.229	0.097	0.019	0.133	0.14	0.131	0.184	1			
InternetUserij	0.168	0.057	0.01	0.283	0.238	0.237	0.3356	0.294	1		
B2Bij	0.337	0.155	0.13	0.292	0.285	0.307	0.3841	0.435	0.4226	1	
B2Cij	0.258	0.122	0.112	0.205	0.394	0.366	0.3361	0.422	0.4059	0.392	1

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